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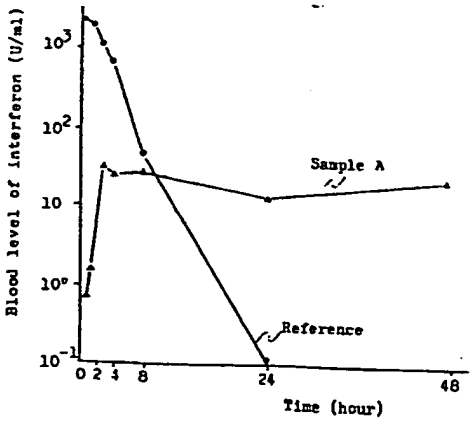
(54) **Prolonged sustained-release preparations.**

(57) A sustained-release preparation in the form of a needle-like or bar-like shape, which comprises an active ingredient and a pharmaceutically acceptable biodegradable carrier (e.g. proteins, polysaccharides and synthetic high molecular compounds, preferably collagen, atelocollagen, gelatin, and a mixture thereof). The sustained-release preparation can be administered to the body or implanted into the body by injection or injection-like methods and can release the active ingredient at an effective level for a long period of time when administered.

Fig. 7

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Our Ref.: T 371 EP
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Sumitomo Chemical Company, Ltd.

# PROLONGED SUSTAINED-RELEASE PREPARATIONS

The present invention relates to prolonged sustained release preparations. More particularly, it relates to prolonged sustained-release preparations in the form of bar-like or needle-like shaped preparations suitable for injection or injection-like administration, which comprise an active ingredient in admixture with one or more of pharmaceutically acceptable biodegradable carriers which can be implanted into the body.

It is known that a medicament can be prepared in such a form that the medicament is embraced within a polymer, for example a polyethylene glycol diacrylate polymer, and is implanted into the body in order to sustain the release of the medicament. However, such a technique has various drawbacks in that the polymer is not biodegradable and hence it must be removed somehow after administration and in that the implantation must be done by operation with troublesome treatment. Nevertheless, it has been desired to create a sustained-release preparation for many medicaments.

The present inventors have intensively studied on an improved sustained-release preparation for medicaments, and have found that the desired sustained-release preparation can be obtained by admixing an active ingredient with a specific biodegradable carrier and that the formed product of the preparation in the form of a bar-like or needle-like shape is very useful for injection or implanting for

body and shows excellent effects with respect to release-sustaining of the active ingredient.

An object of the present invention is to provide an improved sustained-release preparation. Another object of the invention is to provide a long (i.e. prolonged) sustained-release preparation in the form of bar-like or needle-like shaped preparations which can be injected or implanted into the body and can release the active ingredient and can maintain the desired level of the active ingredient in blood or in lesional region for a long period of time. A further object of the invention is to provide a device for administering a sustained-release preparation in the form of a needle-like or bar-like shape. These and other objects and advantages of the present invention will be apparent to persons skilled in the art from the following description.

The sustained-release preparations of the present invention are in the form of a bar-like or needle-like shaped preparation, which comprises (i) an active ingredient in admixture with (ii) one or more pharmaceutically acceptable biodegradable carriers which can be absorbed or be subject to enzymolysis in the body and can be implanted within the body, such as proteins (e.g. collagen, gelatin, albumin), polysaccharides (e.g. chitin), or high molecular compounds (e.g. polylactic acid, polyglutamic acid). The sustained-release preparation is formed in a bar-like or needle-like shape and can be injected or implanted into the body.

The active ingredient used in the present invention is not specified, but includes particularly medicaments which are effective in a very small amount and promote their activity by release-sustaining, for example, indomethacin, prostagrandins, prostacyclines, various bio-hormones, adriamycin, bleomycins, tespamin (triethylenethiophosphoramide), mitomycin, interferon, interleukin, tumor necrosis factor. The active ingredient includes also 4-carbamoyl-imidazolium-5-oleate (other name: 4-carbamoyl-5-hydroxy-imidazole or SM-108) or a salt or a hydrate thereof, known as a new antitumor agent and effective as a metabolic antagonist in purine de novo synthesis.

Interferon, interleukin, and tumor necrosis factor are somewhat different to each other, but are common in that they have very similar molecular weights and are glycoproteins or proteins and have similar pharmacological and physico-chemical properties as α-interferon as will be shown in experiments hereinafter. Prostaglandins, prostacyclines, adriamycin, tespamin, mitomycin are different each other, but they have in common that they have similar molecular weights as indomethacin or SM-108, as will be shown in experiments hereinafter. All of these compounds are prepared for the desired excellent sustained-release preparation of the present invention.

The biodegradable carrier used in the present invention means a carrier which can easily be absorbed or be subject to enzymolysis in the body and can be implanted into the

body. Suitable examples of the biodegradable carrier are proteins such as collagen, gelatin, albumin; polysaccharides such as chitins; and synthetic high molecular compounds such as polyglycolic acid, polylactic acid, polyglutamic acid, or the like. These substances can be used alone or in any combination of two or more thereof, but for reasons of safety and easy handling, collagen or gelatin or a mixture thereof are preferable. Collagen is a main protein of the connective tissue of animals and has less antigenicity, and hence, has widely been used as a safe operation yarn in various medical operations. The collagen may be an atelocollagen having far less antigenicity which is obtained by removing the telopeptide region by treating collagen with an enzyme (e.g. pepsin) in order to make it safer. Gelatin is a protein derived from collagen. Gelatin is a high molecular weight amphoteric electrolyte which has less antigenicity and convertibility properties between sol and gel forms and is low in costs, and hence it has already been accepted as a safe substance for medical use.

The preparation of the present invention contains the active ingredient in an amount of in which the active ingredient is usually used. For example, indomethacin is usually contained in an amount of 0.5 to 500 mg, preferably 1 to 200 mg per dosage unit, and interferon is usually contained in an amount of $10^4$ to $10^9$ IU, preferably $10^5$ to $5 \times 10^8$ IU per dosage unit, and SM-108 or a salt or hydrate thereof is usually contained in an amount of 1 mg to 2 g, preferably 10 mg to 1 g per dosage unit.

Besides, the ratio of the medicament and the carrier is not specified, but for example, indomethacin is preferably incorporated in an amount of 0.005 to 1 mg per 1 mg of the carrier, interferon is preferably incorporated in an amount of $10^3$ to $10^8$ IU per 1 mg of the carrier, and SM-108 is preferably incorporated in an amount of 0.01 to 1 mg per 1 mg of the carrier.

The sustained-release preparation of the present invention can be prepared by the following method.

An active ingredient or an aqueous solution thereof is mixed with a biodegradable carrier or an aqueous solution thereof, and the mixture is homogeneously mixed by stirring while preventing occurrence of foam as much as possible. The resulting mixture is optionally concentrated at a low temperature and further optionally spray-dried or lyophilized. In the preparation, there may optionally be incorporated conventional pharmaceutically acceptable additives such as stabilizers, preservatives, local anesthetic agents, and some agents for aiding formability into special shapes of preparations or for release-sustaining of the active ingredient. These additives are not specified, but suitable examples of the agents for aiding formability are methylcellulose, ethylcellulose, hydroxypropylcellulose, polyvinylpyrrolidone, glycolic acid-lactic acid copolymer, polyethylene glycol, propylene glycol, ethyl alcohol, or the like. Suitable examples of the agents for aiding release-sustaining of the active ingredient are cellulose acetate phthalate, ethylcellulose,

methylcellulose, hydroxypropylmethylcellulose, calcium phosphate, lactic acid-glycolic acid copolymer, corn starch, rice starch, potato starch, cellulose, arginates, or the like.

The preparation thus obtained is pulverized to powders under cooling with dry ice or liquid nitrogen, or by any other conventional pulverization method. The powder is compressed together with other additives if specific shapes should be formed, such as a needle-like or fine bar-like shaped preparations (diameter: about 0.5 mm - 1.5 mm, length: about 5 mm - 15 mm), which can be inserted into a body with a forceps needle for fiberscope, an indwelling needle, or other appropriate administration device as mentioned hereinafter. Alternatively, the powdery preparation is previously entered into a mold, followed by concentrating at a low temperature or by lyophilizing to compress and form a needle-like or a fine bar-like shaped preparation.

All steps for preparing the desired sustained-release preparations are carried out under sterilized conditions because the preparations are used as an injection or for implanting into a body.

The long sustained-release preparation of the present invention can be administered to the patients by various methods, for example, by inserting a fine tube into the body at the desired region with an appropriate means, such as a catheter and then inserting the needle-like shaped preparation of the present invention by passing through inside the fine tube, or by inserting the preparation of the

present invention directly into the body at the lesional region by means of forceps needles of a fiberscope.

The present invention provides also an improved device for administering the needle-like or bar-like shaped preparations of the present invention.

The device for administration of the sustained-release preparation and the mode of their administration are explained referring to the accompanying drawings.

Fig. 1 shows an embodiment of a device for administering the preparation of the present invention which comprises a fine tube and an inner needle.

Fig. 2 is an embodiment showing a state where the device as shown in Fig. 1 is stabbed into the body.

Fig. 3 is an embodiment showing a state where a needle-like shaped solid preparation is administered into the body by the device as shown in Fig. 1.

Fig. 4 shows an embodiment of a needle for administering a needle-like shaped solid preparation of the present invention wherein the solid preparation is held in the needle.

Fig. 5 is an embodiment showing a state where the needle-like shaped solid preparation is administered into the body with the administration needle as shown in Fig. 4.

Fig. 6 is an embodiment of a needle for administering a needle-like shaped solid preparation of the present invention which is provided with a removable cover for preventing the solid preparation contained therein from falling down.

Fig. 7 is a graph showing the relation between the blood level of an active ingredient and the time elapsed after intramuscular administration of the preparation in rabbits.

Fig. 8 is a graph showing the rate of releasing of the active ingredient from the needle-like shaped sustained-release preparation of the present invention.

The device for administering a needle-like shaped preparation comprises (i) a fine tube and (ii) an inner needle which can freely slide within the fine tube.

The fine tube in the above device is a tube having an inner diameter of 0.5 to 5 mm which can be inserted partly into a body. The length of the tube is not specified but may be any size convenient for injection, and is usually in the range of 2 cm to 10 cm. The material for preparing the tube may be any kind of material compatible with the body. The inner needle has a sharp tip as shown in the accompanying Fig. 1 and has an outer diameter as the same as or smaller than the inner diameter of the above tube.

The device for administering a needle-like shaped preparation is usually used with being held in a holding device (6), but may be used with being held at the tip of forceps needle of fiberscope.

The administration manner of the needle-like shaped preparation with the above device is explained in more detail below. Firstly, the inner needle (1) is stabbed into a portion of the body (2) and simultaneously the fine tube (3) is inserted into the body by sliding its inner wall

along the outer wall of the inner needle (1) (cf. the accompanying Fig. 2). Thereafter, the inner needle (1) is pulling off, and then the needle-like shaped preparation (4) is inserted into the body by passing through the inner slit of the fine tube (3), and finally the fine tube is taken off. The insertion of the needle-like shaped preparation into the body is usually carried out by inserting the preparation into the fine tube after pulling off of the inner needle (1), pushing the preparation with a pushing pole (5) till the inside of the body (2) (cf. the accomapanying Fig. 3). The pushing pole (5) may be any pole which can be inserted into and can freely slide inside the fine tube (3), and the above inner needle (1) may also be used as the pushing pole.

In order to insert the preparation of the present invention into a deep region of the body, i.e. internal organs such as stomach wall, the device for fiberscope may be used, and by easily handling the fiberscope, one can effect procedures such as stabbing of the inner needle, insertion of the fine tube, pulling off of the inner needle, administration of the preparation and taking off of the fine tube.

The preparation which can be administered by the above device may be any one of needle-like or bar-like shaped preparations which can be inserted and held within the fine tube (3).

Alternative devices for insertion of the needle-like shaped solid preparations are injection needles provided

with a inner pushing pole which can smoothly slide within the slit of the needle. The injection needles include conventional injection needles. The pushing pole has an outer diameter which is the same or smaller as the inner diameter of the injection needle and it can push a needle-like shaped solid preparation having a diameter of 0.5 to 5 mm.

The device for insertion of a needle-like shaped solid preparation may be held with a conventional holding device (7), but it may also be used by holding it at the tip of forceps needle for fiberscope.

The administration manner of the needle-like shaped solid preparation of the present invention is explained in more detail below.

Previously, the needle-like shaped solid preparation (9) is held within the injection needle (8) (cf. the accompanying Fig. 4), and the injection needle (8) is stabbed at the portion of the body (11) and simultaneously the preparation is administered into the body (11) by pushing it with a pushing pole (10) (cf. the accompanying Fig. 5). In order to administer the preparation to deeper regions of the body such as the stomach wall, it may be administered with a fiberscope as mentioned above. In such a case, for preventing of falling down of the preparation from the needle, it is preferable to provide a removable cover (12) at the tip of the needle (cf. the accompanying Fig. 6). The solid preparation useful for the above administration may be in any form such as needle-like or

bar-like shape which can be held in a conventional injection needle.

As is explained above, according to the device for injection of the present invention, the preparation of the present invention can easily be administered, for example, by insertion into the internal organs (with a fiberscope) and for administerating systematically or topically at the body surface (with a device or needle as mentioned above). These methods are practically and clinically very useful, and it is a novel idea that a biodegradable solid preparation is administered in the above-mentioned manner.

The present invention is illustrated by the following Experiments and Examples, but should not be construed to be limited thereto.

Experiment 1

There were used as the test samples a needle-shaped preparation of α-interferon-collagen prepared in Example 1 disclosed hereinafter (Sample A) and a reference (an aqueous injection of α-interferon originated from Namalwa cells). The test samples were each administered intramuscularly to rabbit, and the change of level in blood of the active ingredient with lapse of time was measured by RIA (radioimmunoassay) method. Two rabbits were used for each sample, and the test samples were each administered in a dose of $10^6$ U/kg. The measurement of blood levels was performed in average in two rabbits.

The results are shown in the accompanying Fig. 7. In Fig. 7, ▲ is the graph of Sample A, and ● is that of reference (α-interferon aqueous injection). As is clear from the figure, Sample A showed release-sustaining, and even after 48 hours, a blood level of several tens unit/ml was maintained.

Thus, it is also suggested by the test of in vivo using rabbits that the preparation of the present invention is useful clinically.

Experiment 2

In order to test the release rate of indomethacin from the sustained-release preparation of the present invention (formed in a needle shape), the preparations of Examples 8 and 9 disclosed hereinafter (Samples H and I) and a reference (indomethacin alone) were subjected to a release test by a rotatory basket method with a basket stirring element as defined in U.S. Pharmacopeia.

The results are shown in the accompanying Fig. 8. In Fig. 8, ● is a graph of Sample H, Δ is that of Sample I, and o is that of reference (indomethacin alone). As is clear from the figure, in case of indomethacin alone, it released immediately, but on the other hand, in case of the needle-shaped sustained-release preparation of the present invention, the release continued for more than 10 days.

Example 1

An aqueous solution of α-interferon (titer: 4.9 MU/ml) (100 ml) and 2 % atelocollagen (50 g) are homogeneously mixed while stirring and preventing occurrence of

foam as much as possible. The mixture is lyophilized and pulverized at a low temperature using liquid nitrogen. The pulverized product thus obtained is formed under compression to give a needle-shaped sustained-release preparation (A) wherein interferon is contained in an amount of 10 MU per 1 needle.

Example 2

An aqueous solution of α-interferon (titer, 4.9 MU/ml) (100 ml), 2 % atelocollagen (50 g), human serum albumin (150 mg) and thimerosal (120 μg) are homogeneously mixed with preventing occurrence of foam as small as possible. The mixture is lyophilized and pulverized at a low temperature using liquid nitrogen. The pulverized product thus obtained is subjected to a compression molding to give a needle-like shaped sustained-release preparation (Sample B) wherein interferon is contained in an amount of 10 MU per 1 needle.

Example 3

An aqueous solution of α-interferon (titer, 4.9 MU/ml) (100 ml) and 2 % collagen (50 g) are homogeneously mixed while preventing occurrence of foam as much as possible. The mixture is lyophilized and pulverized at a low temperature using liquid nitrogen. The pulverized product thus obtained is subjected to a compression molding to give a bar-like shaped sustained-release preparation (Sample C) wherein interferon is contained in an amount of 5 MU per 1 bar.

Example 4

An aqueous solution of α-interferon (titer, 4.9 MU/ml) (100 ml) and atelocollagen powder (1 g) are mixed and the mixture is dissolved by adding thereto 0.1 N hydrochloric acid, and the resulting solution is entered into a mold and lyophilized. The lyophilized product is formed under compression to give a needle-shaped sustained-release preparation (Sample D) wherein interferon is contained in an amount of 10 MU per 1 needle.

Example 5

An aqueous solution of α-interferon (titer, 4.9 MU/ml) (100 ml) and gelatin (1 g) are homogeneously mixed at 60°C while preventing occurrence of foam as much as possible. The mixture is lyophilized and pulverized at a low temperature using liquid nitrogen. The pulverized product thus obtained is subjected to a compression molding to give a needle-like shaped sustained-release preparation (Sample E) wherein interferon is contained in an amount of 5 MU per 1 needle.

Example 6

An aqueous solution of α-interferon (titer, 4.9 MU/ml) (100 ml) and atelocollagen powder (1 g) are mixed and the mixture is dissolved by adding thereto 0.1 N hydrochloric acid, and the resulting solution is lyophilized and pulverized at a low temperature using liquid nitrogen. To the pulverized product is added methylcellulose (25 % by weight based on the weight of the pulverized product), and thereto is added distilled water for injection so that the solid content becomes 20 % by weight. The mixture is

kneaded. The kneaded product is entered into a mold, lyophilized, and then, compressed to give a needle-shaped sustained-release preparation (Sample F) wherein interferon is contained in an amount of 10 MU per 1 needle.

Example 7

An aqueous solution of $\alpha$-interferon (titer, 4.9 MU/ml) (100 ml), 2 % atelocollagen (50 g) and tespamin (triethylenethiophosphoramide, which is known as an antineoplastic) (98 mg) are homogeneously mixed while preventing occurrence of foam as much as possible. The mixture is lyophilized and pulverized at a low temperature using liquid nitrogen. The pulverized product thus obtained is subjected to compression molding to give a needle-shaped sustained-release preparation (Sample G) wherein interferon and tespamin are contained in an amount of 10 MU and about 2 mg per 1 needle, respectively.

Example 8

To a 1 % aqueous solution of atelocollagen (200 g) is added indomethacin (4 g), and the mixture is concentrated to about 20 ml. The mixture is poured into a silicone tube and freezed. The tube is cut, and the freezed product is crosslinked with glutaraldehyde in a gaseous phase for 4 days to give a needle-shaped sustained-release preparation (Sample H).

Example 9

To a 1 % aqueous solution of atelocollagen (200 g) is added indomethacin (4 g), and the mixture is concentrated to about 20 ml. The mixture is poured into a silicone tube

and freezed. The tube is cut, and the freezed product is dried. The resulting product is inserted into a larger-size silicone tube wherein 40 % atelocollagen is contained, and is freezed. The freezed product is taken out from the tube and then is crosslinked with glutaraldehyde in a gaseous phase for 4 days to give a double structure, needle-shaped sustained-release preparation (Sample I).

Example 10

Powdery collagen (2 g) is swollen with a small amount of distilled water and is dissolved by adding thereto 0.1N-HCl. To the solution are added SM-108 hydrate (2 g) and sodium hydrogensulfite (100 mg), and is further added distilled water so that the collagen concentration becomes 2 % by weight. The mixture is entered into a mold, lyophilized and then subjected to compression molding to give a needle-shaped sustained-release preparation (Sample J).

Example 11

The needle-shaped preparation obtained in the same manner as described in Example 10 is inserted into a larger-size silicone tube wherein 40 % atelocollagen is contained, and freezed. The freezed product is taken out and then crosslinked with glutaraldehyde in gaseous phase for 4 days to give a needle-shaped sustained-release preparation having double structure (Sample K).

Claims:

1. A sustained-release injection, which comprises an active ingredient and a pharmaceutically acceptable biodegradable carrier in the form of a needle-like or bar-like shape.

2. The preparation according to claim 1, wherein the biodegradable carrier is a member selected from the group consisting of proteins, polysaccharides and synthetic high molecular compounds.

3. The preparation according to claim 1, wherein the biodegradable carrier is a member selected from the group consisting of collagen, atelocollagen, gelatin, and a mixture thereof.

4. The preparation according to claim 1, wherein active ingredient is a member selected from the group consisting of indomethacin, prostaglandins, prostacyclines, bio-hormones, adriamycin, bleomycins, tespamin, mitomycin, interferon, interleukin, tumor necrosis factor, and 4-carbamoyl-imidazolium-5-oleate or a salt or hydrate thereof.

5. The preparation according to claim 1, wherein the active ingredient is a member selected from the group consisting of interferon, interleukin and tumor necrosis factor.

6. A method for the preparation of a sustained-release preparation, which comprises mixing an active ingredient and a pharmaceutically acceptable biodegradable carrier to incorporate the active ingredient in a carrier

matrix, pulverizing the carrier matrix, and then forming into a needle-like or bar-like shape.

7. A device for administering a sustained-release preparation in the form of a needle-like or bar-like shape as set forth in claim 1, which comprises an injection needle and a pushing pole which freely slides within the needle.

8. A device for administering a sustained-release preparation in the form of a needle-like or bar-like shape as set forth in claim 1, which comprises (i) a fine tube and (ii) an internal needle which freely slides within the fine tube.

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Fig. 1

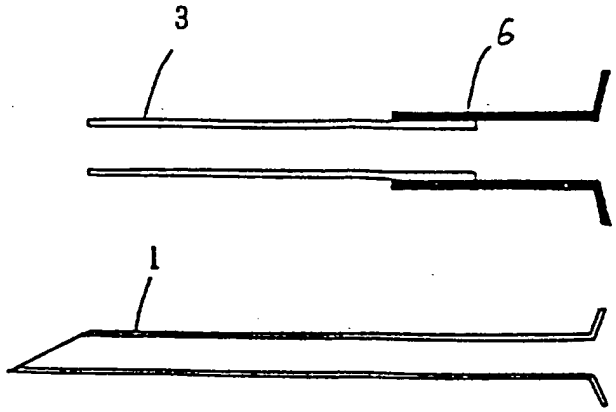



Fig. 2

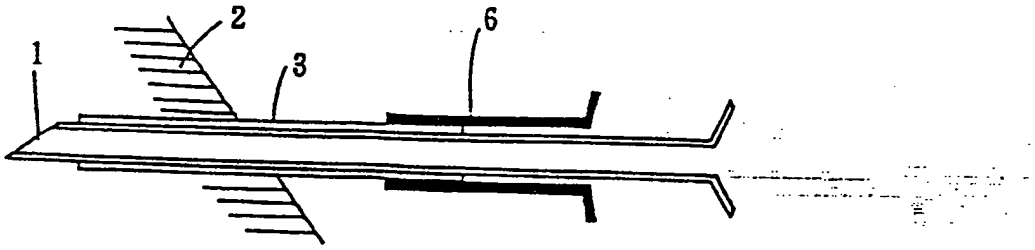



Fig. 3

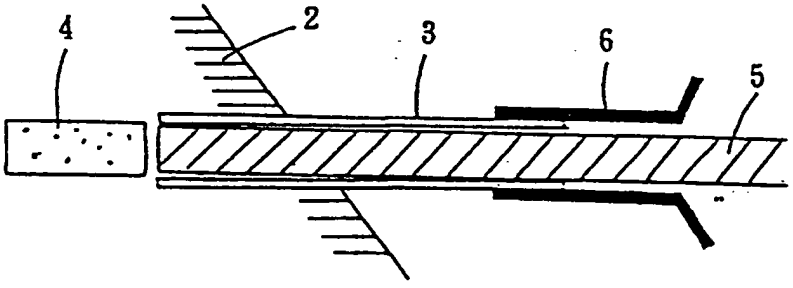


Fig. 4

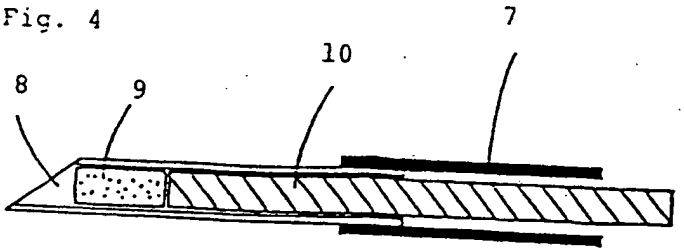



Fig. 5

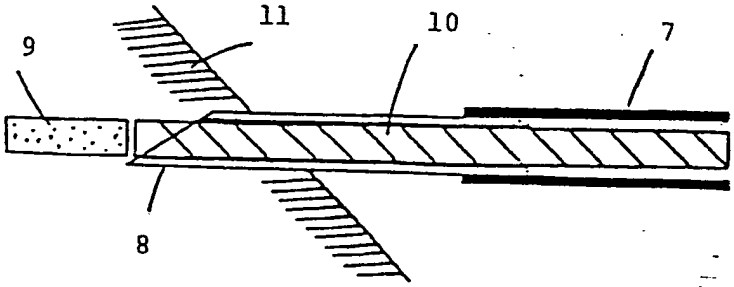



Fig. 6

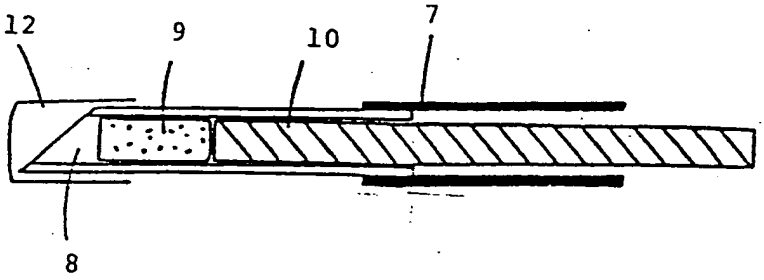


Fig. 7

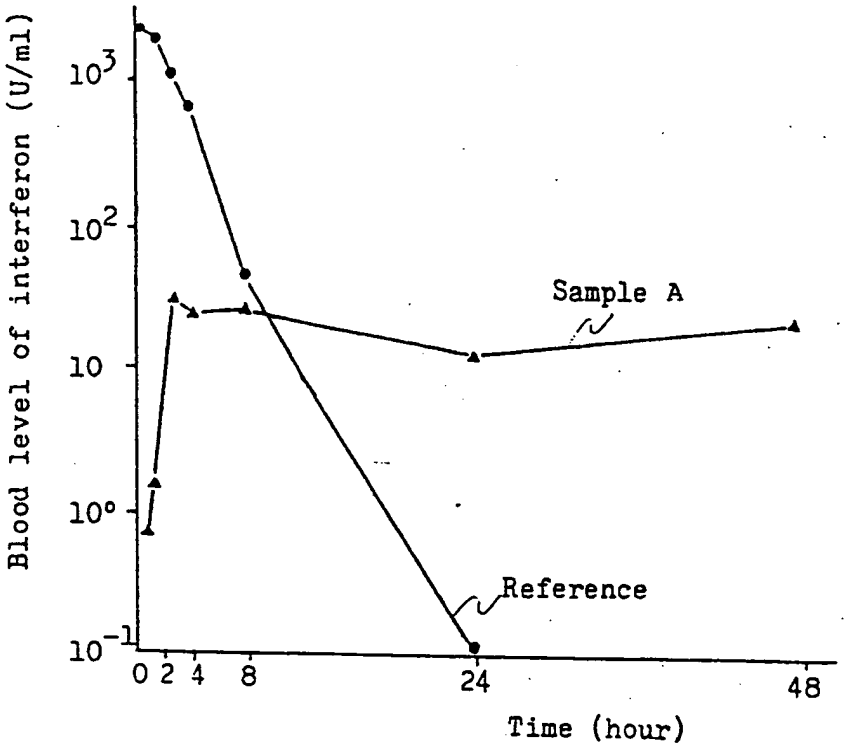
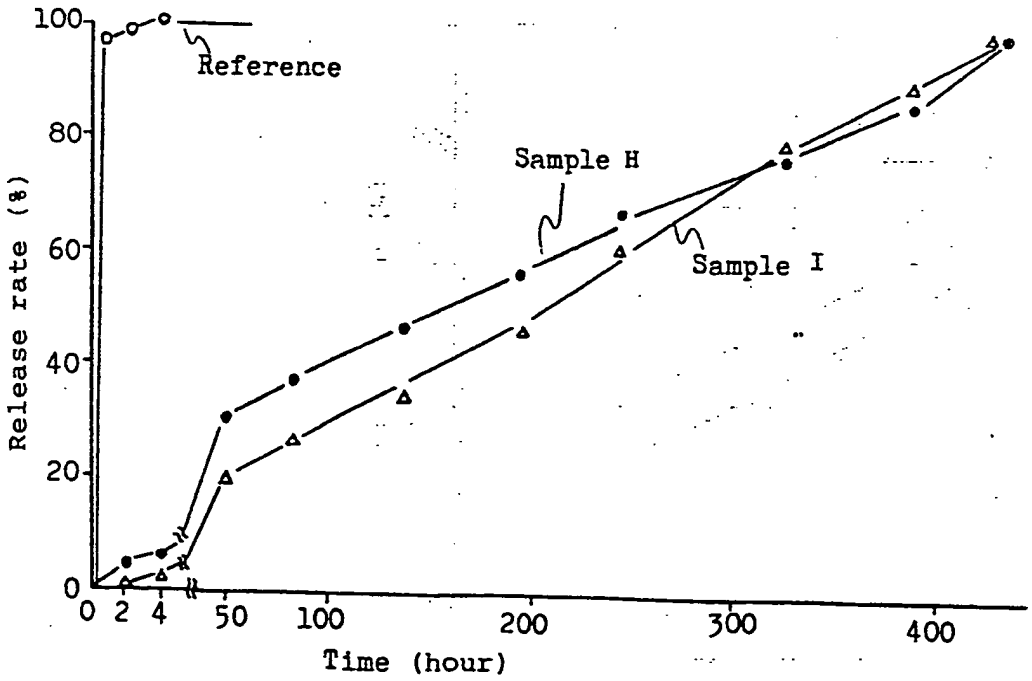

Blood level of interferon (U/ml)
$10^3$
$10^2$
10
$10^0$
$10^{-1}$
Sample A
Reference
0 2 4 8 24 48
Time (hour)

Fig. 8


Release rate (%)
100
80
60
40
20
0
Reference
Sample H
Sample I
0 2 4 50 100 200 300 400
Time (hour)